



## A Tale of Two Systems: Obstacles & Incentives for Implementing Ecological Sanitation in a Periurban Town - Tepoztlán, Mexico

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### ABSTRACT

This presentation will describe efforts to introduce a sustainable ecological sanitation approach within a dynamic, rapidly urbanizing municipality in central Mexico, and examine how the institutional and policy environment helped or hindered implementation of different strategies to address critical water and environmental sanitation issues.

### Project Background

The TepozEco Municipal Ecological Sanitation Pilot Project was initiated in 2003 as a partnership between the local government of Tepoztlán Mexico, the Stockholm Environment Institute (EcoSanRes/SEI) and Sarar Transformación SC<sup>1</sup>. Unlike many other ecological sanitation (EcoSan) pilot projects, which are primarily developing new infrastructure, TepozEco works within an established settlement where it must compete against conventional systems and confront the obstacles of dwellings and neighbourhoods that were not initially conceived with emerging w&s sustainability criteria. TepozEco has thus been described as “retrofitting a small town”.

The main objective of TepozEco has been to implement and demonstrate working examples of closed-loop EcoSan technology and methods in "a street, neighbourhood or community". The challenge is partly technical: to design and adapt ecological sanitation systems to manage and treat separate domestic and community “waste” flows – i.e. human excreta from UD ecological toilets, greywater, and organic solid refuse. However, the Project is

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<sup>1</sup> The TepozEco project has also received technical and financial support from the UNDP/BDP/EEG and the Swiss NCCR-NS research consortium, including EAWAG/SANDEC



also faced with the more daunting task of establishing an appropriate framework for EcoSan to be considered in policy, planning and budget allotments, while the present inertia favours often-unsustainable waterborne solutions.

Significantly, at about the same time that the TepozEco Project began, municipal, state, and federal funds were allocated to construct fully subsidized sewerage for the downtown area of Tepoztlán to serve approximately 21,000 PE.

Although the installation of this conventional wastewater system was initially perceived as a dark cloud hanging over the TepozEco project, it has, in fact, provided an excellent opportunity to compare the two approaches: the conventional waterborne centralized “hard” option and the “soft” household-centered EcoSan option.

### TEPOZTLÁN – A CLASH OF TWO SYSTEMS

During the first 18 months of the Project, TepozEco initiated small pilot activities (e.g. community environmental education, domestic eco-toilet and greywater filter demonstrations) in a number of *barrios* (neighbourhoods) of the municipal seat, as well as periurban *colonias* and towns. These activities permitted the project team to accumulate knowledge and experience of the physical, socio-political environment, test family and community responses to the project initiatives, and refine site selection criteria for integrated demonstration.

Nevertheless, in spite of the increasing evidence of the links between conventional sanitation and environmental and health degradation, and the clear advantages of EcoSan approaches, it has been difficult to convince a significant sector of the population to accept dry ecological toilets as the option of choice. This is particularly the case where urban residents are connected to the water mains and believe that sooner or later their households will be connected to waterborne sewerage— despite the fact that important physical characteristics, such as topography and water availability, seriously mitigate against the possibility of installing a full sewage service.

In the meantime, particularly within the last generation, an estimated 70% of the urban households have installed waterborne septic systems. These are poorly designed and constructed and receive virtually no maintenance, discharging the inadequately treated effluent into subsurface drainage pits and ultimately into underground aquifers. Without appropriate public policies, regulations and incentives –such as a serious water crisis – it seems unlikely that the majority of the urban population will be willing to give up their romance with the WC.

These factors were further compounded by a change in municipal government in late 2003, at the end of the first year of the project, from an aggressively environmentalist local government, to a conservative uncooperative mayor with a divided council. This radical



shift in the project alliances simply served to highlight the critical role of “political commitment”.

### THE “SOFT” OPTION: SAN JUAN TLACOTENCO

This situation gradually led TepozEco to focus attention on the outlying towns where water supply is much less reliable, often requiring tank-truck delivery at as much as US\$3.5/m<sup>3</sup>. After careful consideration, San Juan Tlacotenco, a water scarce, indigenous, periurban community of about 2000, was selected as the site of the initial “intensive” integrated EcoSan pilot program. During 2004 and 2005, with a materials subsidy from the Morelos State Water and Environment Commission (CEAMA), TepozEco worked closely with the community to install 30 integrated domestic EcoSan systems, including dry toilets, greywater management, as well as urine and faeces collection, treatment, and recycling to local agricultural activities.

An important feature of the project has been its focus on capacity building:

- Local families were involved in all stages of decision-making including toilet design, siting, coordination of building materials distribution, and construction.
- Local masons were trained in construction techniques.
- A local youth group was trained and involved in monitoring system operation.
- Local project staff has also been involved in each stage of the project (an experience which they will now be able to transfer to the local government). And
- The SARAR multidisciplinary technical team is now equipped to provide training and consulting services to similar projects.

In addition to the work in periurban San Juan, TepozEco has:

- Designed and demonstrated a range of user-friendly eco-toilet models among an array of users from diverse socioeconomic sectors.
- Developed *Oro Líquido* (liquid gold), a microenterprise to rent and sell portable male and female waterless urinals with a urine harvesting service
- Demonstrated the feasibility of harvesting urine and the advantages of using urine as a fertilizer.
- Provided technical guidance to a Municipal Composting Center, which generated more than 200 m<sup>3</sup> of high quality compost during 19 months of operation.
- Lobbied for constructed wetlands as the most viable alternative for the municipal WWTP.
- Worked with the Association of Architects and representatives of the Municipal Government to draft improved W&S guidelines within the local building code
- Consolidated a multidisciplinary team of EcoSan specialists



## THE “HARD” OPTION

During this same period (2003-2006), government authorities, for all intents and purposes have continued to pursue the conventional route to address the urban sanitation crisis. Due to the significant high costs of the proposed sewerage and lack of effective coordination between government agencies, to date, more than 4 years since the project onset, only a fraction of the planned 7 km collector pipe has been completed and there is no consensus on treatment technology. In the meantime, a portion of the untreated sewage is collected in tank trucks and discharged at the municipal open garbage dump, while the rest flows into a nearby seasonal riverbed.

In spite of this deplorable situation, there is still no apparent plan for cost recovery or rational use of water. Moreover the lack of metering (users are charged a fixed fee regardless of volume consumed) makes it impossible to estimate the impact of full sewerage on groundwater availability. In the meantime, the sewage network has been expanded to two additional downtown streets in the same ad hoc unplanned manner.

In the meantime, the municipal government has signed an agreement with the National Water Commission (CNA) to provide full sewerage coverage and treatment in the municipal seat and two other towns within 5 years. This is part of a federal program, which condones the debt that most municipalities have acquired from fees and fines for the extraction and pollution, respectively, of federal waters. Tepoztlán’s current debt is approximately 1 million dollars. If the infrastructure is not completed –which is the inevitable scenario--, sanctions will follow –again. A vicious cycle in a vicious system.

A recent independent groundwater study of a broad sample of private wells in the valley of Tepoztlán, including the primary source of domestic tank truck water supply, revealed nitrate and coliform levels higher than the potable water norm NOM-127-SSA1-1994<sup>2</sup>. As is frequently the case, at least in the developing and emerging economies, the “hard” option is also the “dirty” option.

## TEPOZECO’S SHORTCOMINGS

But this is not to say that the TepozEco project is exempt from criticism:

1. A range of technical details of the EcoSan solutions in San Juan still need to be resolved. Of particular concern is the lack of a fully institutionalized maintenance support service. In spite of attempts to establish a microenterprise through the local youth group, experience to date indicates that such an enterprise would require greater support from the municipal government in terms of clearly defined regulations and

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<sup>2</sup> Average nitrate and coliform levels



incentives –and possibly a government subsidy. This is not an unreasonable proposal given the significant subsidies involved in installing centralized sewage systems!

2. So far, CEAMA's investment towards EcoSan in San Juan amounts to only 1 percent of conventional sewerage investment planned for Tepoztlán.
3. Although TepozEco succeeded in obtaining serious consideration of treatment wetlands as an option for the municipal WWTP, funds have yet to be fully committed. In fact, it now seems likely that the negotiations will have to be reinitiated after the new municipal, state, and national governments are installed in November! –leaving open the possibility that a less sustainable conventional treatment system might still be selected at the eleventh hour.
4. TepozEco's proposal to work towards developing a more efficient municipal water (and sanitation) service provider has not found support from the current Municipal Government. Nevertheless, the team is still working on proposals in the hope that the next municipal government will be more cooperative.
5. Although the Municipal Composting Center started well, TepozEco decided to withdraw temporarily when the city garbage dump caught on fire for the second time in a year, creating a serious health hazard to the workers due to toxic fumes. In order for the initiative to be renewed it will be necessary to resolve other underlying issues related to institutional support and transparency from both the local government and the local farmers association (*Comisariado Ejidal*).
6. The new building code has yet to be approved by the town council and it is unlikely that the outgoing municipal government will even put it on the discussion table.
7. While TepozEco has been able to initiate and demonstrate valuable EcoSan activities, the project still falls short in creating an environment that could guarantee the spontaneous replicability of EcoSan.

## **ECONOMIC, ENVIRONMENTAL, AND SOCIAL COMPARISON OF TWO SYSTEMS**

The experience in Tepoztlán has provided a unique opportunity to compare conventional and ecological sanitation within a specific municipal context. Our primary state government counterpart, CEAMA, has recognized the significance of the small pilot project in San Juan Tlacotenco as a possible model for alternative integrated periurban services in the larger cities of Morelos state. In order to have documented evidence to present to the state legislature, the Commission specifically requested that TepozEco systematically compare the ecological sanitation option with the conventional approach, which is where they continue to invest the greater resources.

Following is a summary table prepared by SARAR specialists (Kim Andersson and Jacinto Buenfil), which compares the evolving EcoSan system in San Juan with the hypothetical implementation of a conventional system in the same community. The data for the latter stems from the proposed sewerage and WWTP for downtown Tepoztlán.



**Table 1.** Comparison table for EcoSan and conventional sanitation system for the San Juan Tlacotenco village.

Sanitation system	Economy (US Dollar)				Environmental impact		Annual water use (liters per family)	Recycling of nutrients and organic material	Orientation of responsibility
	Initial investments		Oper. & maintenance		Effluent*** (kg/año)	Soil			
	Family level	Community level	Family level	Community level					
Ecosan	1,100 ①	46,000 ②	12 ③	2,800 ④	BOD: 0 Nitrogen: 0 Phosphor.: 0	Improves fertility	0	High	User/ community
WC, sewage system with treatment	1,600 ⑤	690,000 ⑥	80 ⑦	7,500 ⑧	BOD: 1,360 Nitrogen: 450 Phosphor.: 180 ⑨	No direct impact	45,000 ⑩	Low	Government

**1. Construction cost for EcoSan-family-system**

Material: \$820USD; Labour: \$280USD; Total: \$1,100USD

**2. Community/public cost for EcoSan**

Financial support to form a community-based organization, education, supervision, and follow-up (8 hours per family); ) -- projected investment per family \$115 USD. Total cost for the community (400 families): \$46,000USD

**3. O&M cost per family**

The cost for maintenance depends upon whether the family provides the work themselves or hires the service. The projected annual cost per family for a full recollection service is \$14USD. Total cost (including cost for renewal of material: \$5-19USD; average: \$12USD)

**4. Construction cost for WC-system**

Toilet building: \$1200USD; Water cistern: \$800USD; Total: \$1200-2000USD (average: \$1600USD)

**5. Public cost for operation and maintenance**

Financial support for collection service of urine and faeces. Annual cost for the community (expenses for vehicle and maintenance): \$2800USD (\$7USD per family)

**6. Installation of sewerage and wastewater treatment plant**

Sewage pipe: \$4,800USD per 100 m; In this community ~10,000 m of pipe => \$480,000USD

WWTP: \$210,000USD (Based on the \$2.2 million USD proposal for WWTP in Tepoztlán for 21,000PE)

Total: \$690,000USD



### 7. Water cost for WC

Price per m<sup>3</sup> from water truck: \$4USD

Total water demand for flushing the WC per family: 45m<sup>3</sup>/year

Demand of water from water truck: 14 and 26m<sup>3</sup>/year with or without an extra water tank respectively.

Total annual cost: \$56-104USD (average: \$80USD)

### 8. Projected annual operation and maintenance cost for sewage system and WWTP.

Maintenance of sewage system (100m/year): \$4,800USD

Treatment cost: \$0.038USD/m<sup>3</sup> (based on WWTP-proposal); Wastewater production from WC: ~25liters/day/pers => Cost to the community: \$700USD

Total cost O&M for the community: \$5,500USD/year O&M cost per family: 14 USD/yr

### 9. Effluents from WC (assuming compliance with the Mexican norm, *NOM-001-ECOL-1996*)

Total community wastewater effluent from WC: 18,000m<sup>3</sup>/year

BOD (limit = 75mg/l): 1,350 kg/year

Nitrogen (limit = 25mg/l): 450 kg/year

Phosphorous (limit = 10mg/l): 180 kg/year

### 10. Water use with WC per family

Water use per person: 25 litres/day; per family (5pers): 125 litres/day;

Total: 45,000 litres/year

## SYSTEM COMPARISON ANALYSIS

### Economy:

- **Initial Investment** - The economic comparison, portrayed in the table, demonstrates that the initial investment at a household level is similar for the two systems. However, at a public level the implementation cost of conventional sanitation is 15 times higher than that of EcoSan. The total investment per family for the EcoSan alternative was about US\$1,215 including capacity building and implementation support, while the corresponding cost for the conventional installations would amount to approx. US\$2,925 per family.
- **Operation and Maintenance Cost (O&M)** - The EcoSan installations have an estimated annual O&M cost ranging between US\$12-26 per fam/year, depending on the amount of work the family is willing to perform (a complete urine and faeces collection service would cost about US\$14 per fam/year). A waterborne system with WC would imply an annual estimated cost of US\$ 118 per family/year. The



elevated cost for conventional sanitation is primarily due to the significant increase in water consumption of this system and the high water price that prevails in the community.

### Environmental Impacts:

- **Water Consumption - The EcoSan** toilets in this study do not consume water, while the conventional WC would use water to transport human excreta. The water consumption per household (5 persons) for the WC would amount to approximately 45,000 litres/year – or 18,000,000 litres/year for the whole community. As an indication of the magnitude of this water demand, it is worth mentioning that the newly installed water reservoir in San Juan Tlacotenco has a 20,000,000-L capacity.
- **Discharges** - A core principle of EcoSan is “zero discharge”, due to the use of dry toilets and greywater recycling. The conventional system, however, contributes to water pollution even while complying with the Mexican norm for wastewater discharges. If a wastewater treatment plant - designed to meet the norm - were installed, every household would contribute with an annual effluent discharge of approximate 3.5 kg BOD, 1.1 kg nitrogen and 0.45 kg phosphorous – or, for the entire community: 1,360 kg BOD, 450 kg nitrogen and 180 kg phosphorous.
- **Recycling of Nutrients and Organic Matter** - If made available for agricultural production, human excreta can be a valuable source of nutrients and organic matter.

#### *From contaminants...*

In most waterborne sanitation, the possibilities for recycling nutrients and organic material are limited. In development countries, if wastewater is reused in agriculture, it is often applied without prior treatment generating major health risks in food production. If the water is treated, nutrients and organic content are considered as contaminants and their removal requires significant resources (energy, infrastructure, foreign technology, etc.).

#### *...to resources*

In ecological sanitation human excreta are kept away from the water cycle, thus protecting water bodies. Moreover, after adequate sanitation of urine and faeces (through storage and dehydration respectively), nutrients and organic matter can be safely used as agricultural fertilizers, which increases the recycling potential. Hence, recycling of human excreta, along with other agro-ecological practices, could replace chemical fertilizers. This would render food production more sustainable and have a positive impact on family economy.

### Social Impacts:

In this case study, EcoSan and conventional sanitation offer two distinct approaches to addressing environmental problems. With the conventional method, municipal authorities implement sanitation services without community involvement. In contrast, the EcoSan concept requires the motivation and participation by the individual families involved and therefore ultimately the social acceptance of the



system by the community as a whole. Ecological sanitation thereby offers a shift in the orientation of responsibility from government to families and the local community, both in terms of investments and O&M. This responsibility shift may, in turn, improve the organizational capacity of the community and strengthen the autonomy of the families.

Apart from the 30 families who constructed EcoSan installations in San Juan Tlacotenco, an additional 100 families are interested in implementing similar sanitation solutions. This fact is an evident indication of the social acceptance that EcoSan has gained in the community.

#### ***Conclusions of comparison of Ecosan and conventional systems***

- *Total EcoSan investment is 60% lower than that of conventional sanitation*
- *A WC implies an increase in water consumption of approx. 45,000 litres/family per year.*
- *Despite high investments for ww treatment, the conventional system results in discharges of contaminants, while EcoSan is based on “zero discharge”*
- *From the perspective of conventional sanitation human excreta are seen as contaminants, while EcoSan considers them as resources that should be safely reutilized in agricultural production*
- *If EcoSan gains social acceptance, it could strengthen the autonomy of families and communities*

### **LESSONS LEARNED – THE FORCE FIELD**

Whereas the data seems to clearly support the justification for the “soft” EcoSan path, the significant efforts and resources (more than \$100,000/year over 3.5 years) invested by TepozEco seem to have been overwhelmed by the inertial forces favouring conventional, and frequently unsustainable, sanitation. Thus far, the project has made very limited headway in moving from a pilot phase to some sort of meaningful scale. We also feel that time is running out –for water resources, the environment, as well as for the project. Perhaps it is useful to briefly examine some of the potential lessons that could be extrapolated to other projects:

#### **Socio-cultural (attitudinal)**

- Unfortunately most people are simply incapable of “seeing” the problem. Conventional water-based systems that simply transfer the problem downstream contribute to this insidious out-of-sight-out-of-mind mentality.
- Most people who embrace EcoSan are either faced with critical water scarcity and/or have a higher awareness regarding environmental issues. In addition, in places where conventional latrines or open defecation have been the norms, people tend to consider ecological dry toilets as a significant step up the sanitation ladder.



- Although the resource value of reused eco-san toilet products has seldom been a major driving factor, in San Juan, an agricultural based periurban community, this is gradually becoming a motivating factor as well.

**Structural** - Unfortunately the structural forces that favour conventional sanitation – and act as barriers to the introduction of more sustainable ecological approaches – are proving to be the most difficult to overcome. Among the most prevalent:

- As long as there is lack of an integrated vision, capacity and commitment at the local government level, progress will be slow and valuable resources will be wasted. **Political commitment is the sine qua non for going to scale with sustainable sanitation.**
- Water and sanitation sector decisions are frequently dominated by political and financial concerns instead of the best interest for either the environment or people. For example, short government terms –only 3 years at the municipal level– make big, fast, and visible projects politically more attractive than small, decentralized, long-term solutions.
- Construction and consulting firms, technicians and politicians often have a vested interest in business as usual particularly where large infrastructure projects are concerned –which provide opportunities for large contracts and corruption.
- Having said that, it is also true that local authorities, engineers, and other key decision-makers are simply unfamiliar with – or conservatively suspicious of – alternative options. And, of course, there is little hope of changing the status quo as long as the official sector is unwilling to support serious research and development of alternative solutions at any meaningful scale. Instead, investment is geared towards conventional water-based sanitation, which in Mexico, as in most of Latin America, is spewing almost 90% of wastewater virtually untreated into the environment with enormous health and environmental consequences. (It should be noted, however, that this is not predominantly a technical issue. Treatment plants fail not because the technology is bad per se, but because there is seldom enough money or capacity to operate and maintain them, which does raise serious questions on their appropriateness.)
- Lack of financing mechanisms for users who favour EcoSan. The "polluter pays" principle should be applied at every level of the chain so that users are faced with financial consequences for environmentally harmful choices – and, in turn, be rewarded for ecological ones. This would enable local authorities to facilitate more sustainable options.
- Inexpensive credit and financing mechanisms should be made available to both new homeowners as well as those who are interested in retrofitting their existing



dwelling– often a considerably more expensive proposition. Outright subsidies can help get things started, but unless they are accompanied by a clear phase-out, they can also seriously inhibit spontaneous self-replication.

Ecosan technology is still at its infancy. Despite its 10 years of serious consideration as an alternative, it must compete against a system with more than 100 years of allocated investment, policy, and research. For EcoSan to be widely accepted, the comfort and service level must be similar to that which the WC currently offers. Otherwise it will always be seen as the solution for the poor, the rural, the “crazy environmentalists” -- everyone but the average citizen.

### WHO IS LISTENING? – HOPEFUL SIGNS ON THE HORIZON

Although the slow progress with the project has often been frustrating; in retrospect, it now seems distinctly farsighted that Sarar Transformación pursued a multilevel strategy from the outset. Specifically, a key objective of the TepozEco Project approach has been to develop an experiential and knowledge base from which to influence multi-sectoral development policies and activities that promote the sustainable management of w&s services in municipalities throughout Latin America and the Caribbean. As a result, to the extent that resources permitted, the SARAR team has been continually involved in lobbying and networking to share and disseminate the lessons learned and skills acquired through the TepozEco project.

In this regard, the 4<sup>th</sup> World Water Forum, which took place in Mexico City in March 2006, proved to be an ideal opportunity to strengthen networks and partnerships, raise the general profile of EcoSan, and broadly share the TepozEco project with all its achievements and limitations.

Although progress has often seemed slow locally, we now see encouraging signs at several levels:

1. **San Juan Tlacotenco**– Now, after more than a year of careful monitoring and support of the Ecosan demonstration household installations, most families have shown that they are able to adequately operate and maintain them without additional external support. The use of participatory tools and methods, especially at the community level, has generated significant gains in terms of commitment and awareness raising. As stated above, 100 additional families have requested support in building their own ecological systems.
2. **Municipality of Tepoztlán** – In the recent elections, the people of Tepoztlán voted overwhelmingly for what promises to be a more environmentally aware government, during the 2007-2009 period. The project is particularly encouraged that two of its own trained local staff members have been invited to join the government elect in November



of this year. We are also receiving a greater number of visitors at the Sarar/TepozEco demonstration center, both individual families and representatives of local communities.

3. **State and watershed** - A greater number of partners have approached Sarar Transformación seeking to collaborate at water basin and state levels. We are particularly encouraged by initiatives from various local and state institutions – e.g. Morelos State University, Mexican Institute of Water Technology (IMTA), CEAMA, neighbouring municipal governments and civil society organizations – which are seeking to coordinate efforts at the micro-basin and bioregional levels.
4. **National (Mexico)** – The WWF4 raised awareness of both general water issues and Ecosan in particular. Civil society organizations appear to have acquired a stronger collective voice, as well as more credibility and communication with certain elements of the national and state water authorities.
5. **Regional and international** - Particularly encouraging is the increasing number of new initiatives in Central and South America that are looking to Sarar/TepozEco as an inspiration and potential partner to investigate and implement Ecosan approaches as an option for addressing serious environmental problems, while increasing sanitation coverage.

Our challenge now is how to adequately respond to these growing external demands, while continuing to build a model and example at the local level.

## CONCLUSIONS

A great challenge of 21st century is to shift the momentum of the W&S sector, currently driven by linear, end-of-pipe uni-sectoral thinking, into a more holistic and sustainable paradigm. Whereas it is becoming tragically evident that the challenges of the MDGs cannot be addressed through conventional centralized top-down approaches --as the TepozEco experience has demonstrated -- existing laws, institutional arrangements, and financial mechanisms seriously inhibit – if not prohibit – alternative, community based decentralized solutions. Sarar Transformación is, therefore, joining hands with other national and international experts to invite local, state, and national stakeholders to engage in a constructive dialogue to consider testing sustainable sanitation alternatives on a broader scale.